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(54) Title of Invention: **A Printed Wiring Board Contact Hole Machining Method**

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(57) **ABSTRACT**

Problem

To provide a printed wiring board contact hole machining method. [sic] Which permits attainment of reduction in labor during work operations, simplification of manufacturing processes, and reduction in cost; which produces cleanly finished contact holes allowing satisfactory adhesion of plating; and which improves product yield.

Solution Means

As at operations A and B, copper foil 11 applied to base material 10 is etched, forming an internal-layer circuit, and copper foil 15 is adhered over intervening resin 14 to produce substrate 16. Next, as at operations C and D, laser light 17 is directly irradiated from above laminated copper

foil 15, forming contact holes 18 and 19. Here, copper foil 15 is not used as laser light mask, but instead laser light directly irradiates the copper foil itself to accomplish hole formation machining, eliminating [the need for] an operation for etching of contact holes in copper foil 15. Laser light 17, of specific wavelength and of diameter smaller than that of the contact hole, is made to revolve in spiral fashion from a central region at which a hole has been formed, and as this is done the wall of the hole is removed and the hole is enlarged to machine a prescribed contact hole. As a result, contact hole etching can be eliminated and contact hole walls are cleanly finished.

CLAIMS

(1) In the context of a printed wiring board contact hole machining method wherein a metal layer is laminated onto base material over an intervening adhered insulator layer and contact hole machining is carried out with laser light, a machining method characterized in that laser light is directly irradiated from above the aforesaid metal layer and hole formation machining of the aforesaid metal layer

itself and the aforesaid adhered insulator layer is carried out.

(2) In the context of a printed wiring board contact hole machining method wherein a metal layer is laminated onto base material over an intervening adhered insulator layer and contact hole machining is carried out with laser light, a machining method characterized in that hole formation machining is carried out as the aforesaid laser light is made to revolve in spiral fashion from the central region of the location at which the aforesaid contact hole is to be formed.

(3) In the context of a printed wiring board contact hole machining method wherein a metal layer is laminated onto base material over an intervening adhered insulator layer and contact hole machining is carried out with laser light, a machining method characterized in that laser light is directly irradiated from above the aforesaid metal layer and hole formation machining of the aforesaid metal layer itself and the aforesaid adhered insulator layer is carried out as the aforesaid laser light is made to revolve in

spiral fashion from the central region of the location at which the aforesaid contact hole is to be formed.

(4) A machining method according to claim 1, 2, or 3 wherein the aforesaid contact hole is a contact hole that either extends [completely] through or does not extend [completely] through substrate.

(5) A machining method according to claim 1, 2, or 3 that permits those of the aforesaid contact holes that are non-through-hole contact holes to be machined to an arbitrary depth.

(6) A machining method according to claim 1, 2, or 3 wherein the aforesaid laser light [possesses] a beam diameter that is less than the diameter of the aforesaid contact hole.

(7) A machining method according to claim 1, 2, or 3 wherein ultraviolet light of one of wavelengths 157 nm, 193 nm, 248 nm, 266 nm, 308 nm, 351 nm, or 355 nm is employed as the aforesaid laser light.

(8) A machining method according to claim 1, 2, or 3 wherein the aforesaid base material [comprises] a glass,

paper, aramid, teflon, or like core material that has been impregnated with epoxy, phenolic, polyimide, or other such resin.

(9) A machining method according to claim 1, 2, or 3 wherein the aforesaid adhered insulator layer comprises epoxy, phenolic, polyimide, or other such resin.

(10) A printed wiring board manufacturing method characterized in that it possesses a metal layer lamination operation wherein a metal layer is further laminated over intervening resin onto a substrate on which an internal-layer circuit has been formed; a contact hole machining operation wherein, as a result of direct irradiation of laser light from above the aforesaid metal layer, metal layer and resin are removed and a non-through-hole contact hole that reaches the internal-layer circuit or a contact hole that extends [completely] through the laminated substrate is formed; and an external-layer circuit formation operation wherein plating is applied to the laminated substrate on which the aforesaid contact hole has been formed and a circuit pattern is formed in an external

metal layer.

(11) A manufacturing method according to claim 10 wherein a multilayer printed wiring board on which a multiplicity of metal layers have been laminated is manufactured as a result of returning to the aforesaid metal layer lamination operation and passing through the aforesaid contact hole machining operation after passing through the aforesaid external-layer circuit formation operation.

DETAILED DESCRIPTION OF THE INVENTION

[0001] *Technical Field of the Invention*

The present invention concerns a printed wiring board contact hole machining method, and in particular pertains to a printed wiring board contact hole machining method permitting simple and precise hole formation machining in laminated printed wiring board regardless of whether the contact holes are to be through-holes or non-through-holes.

[0002] *Conventional Art*

Printed wiring board ordinarily [comprises] a base material (core member) of glass, paper, aramid, teflon, or

like core material impregnated with epoxy, phenolic, polyimide, or other such resin, over which copper foil, serving as metal layer, is adhered, this copper foil being etched and a prescribed circuit pattern formed therein, and [another] copper circuit pattern likewise being further formed over intervening resin over this. Through-hole or non-through-hole contact holes are mechanically formed in substrate laminated in this fashion and plating is applied thereto to produce the printed wiring board.

[0003] Miniaturization, increased speed, and increased capabilities in electronic equipment in recent years have been striking, and the volume occupied by equipment containing printed wiring boards having become a problem, a method of manufacturing a multilayer printed wiring board wherein "via holes," smaller than those [produced by] mechanical contact hole formation techniques, might be formed by a laser machining method is desired (see, for example, Japanese Examined Patent Application No. HEI 4[1992]-3676). Furthermore, Japanese Examined Patent Application No. HEI 4[1992]-47999 describes a printed

wiring board machining method characterized in that, in performing through-hole formation, groove formation, outline cutting or other such machining of wiring board wherein a metal layer has been adhered over the main body of the substrate, the aforesaid metal layer over this machining region is selectively etched in a pattern corresponding to that according to which this machining is to be carried out, following which this metal layer is used as a mask and through-hole formation, groove formation, outline cutting or other such machining is performed on the aforesaid substrate main body by means of laser machining.

[0004] *Problem to Be Solved by the Invention*

As described above, in conventional contact hole formation methods, such as are described in Japanese Examined Patent Application No. HEI 4[1992]-3676, Japanese Examined Patent Application No. HEI 4[1992]-47999, or the like, copper foil or other such metal layer has been used as a mask during irradiation of laser light, the metal layer has been etched and removed beforehand at a location corresponding to a contact hole, this metal layer has been

used as a mask during irradiation of laser light, and a contact hole has been formed in resin at the corresponding location where the metal layer is absent.

[0005] For this reason, an operation wherein the location corresponding to contact hole formation is removed beforehand by means of etching or the like has been required. Furthermore, there has been the problem that when forming holes using laser light, because one has had to employ laser light of power such as will permit removal of resin but preserve the metal layer to be used as mask, the hole interior could not be finished cleanly. For example, melting of glass at a location at which glass fabric, serving as core material, is being cut by laser light causes production of glass globules (e.g., 5 μ - 50 μ in diameter), and complete plating of such glass globules has been difficult.

[0006] Moreover, when forming prescribed passage holes in metal films by means of etching, such as is described in Japanese Examined Patent Application No. HEI 4[1992]-47999, it has also been difficult to consistently maintain

expected precision with respect to hole diameter and positional accuracy and the like because of the fact that etchant concentration, composition, and so forth undergo subtle changes with the passage of time.

[0007] The object of the present invention is to provide a printed wiring board contact hole machining method characterized in that it permits attainment of reduction in labor during manufacturing operations, and in that it permits simple and precise hole formation machining in laminated printed wiring board regardless of whether the contact holes [formed therein] are to be through-holes or non-through-holes.

[0008] *Solution Means*

In order to achieve the aforesaid object, the present invention, in the context of a printed wiring board contact hole machining method wherein a metal layer is laminated onto base material over an intervening adhered insulator layer and contact hole machining is carried out with laser light, is characterized in that laser light is directly irradiated from above the aforesaid metal layer and hole

formation machining of the aforesaid metal layer itself and the aforesaid adhered insulator layer is carried out. For this reason, because copper foil or other such metal layer is not used as mask, elimination of the conventional operation wherein etching for formation of contact holes in the metal layer is carried out is permitted. Furthermore, [the present invention] is characterized in that hole formation machining is carried out as the aforesaid laser light is made to revolve in spiral fashion from the central region of the location at which the aforesaid contact hole is to be formed. For this reason, it is possible to employ laser light of power such as will permit clean removal of glass fabric or other such core material--for example, [laser light] of beam diameter less than the diameter of the contact hole, or of a prescribed wavelength in the ultraviolet region--and by so doing to permit clean finishing of the hole interior.

[0009] *Manner of Implementation of the Invention*

Below, we describe manner(s) of implementation of the present invention with reference to drawings. FIG. 1

contains diagrams of manufacturing operations in one manner of implementation of the present invention, these being cross-sectional diagrams of the substrate in a four-layer printed wiring board as it passes from an operation A to an operation G. First, as shown at operation A, copper foil (metal layers) 11 applied to both faces of base material 10 is etched, forming internal-layer circuit patterns and lands. Base material 10 comprises glass serving as core material 12 which is impregnated with resin 13, and [the two taken together] may also be referred to as the core member.

[0010] In addition to glass, one may also use paper, aramid, teflon, or the like as material for core material 12. In the present manner of implementation we have employed a base material 10 possessing a core material 12, but the present invention may also be adopted to a base material consisting only of resin, wherein the core material is absent. Furthermore, epoxy, phenolic, polyimide, or other such resin may be used as resin 13, which acts as adhesive and electrical insulator. Also, silver, aluminum or other

such electrically conductive metal may be used in place of copper.

[0011] Next, in the lamination operation as shown at operation B, copper foil 15 is further adhered over intervening resin 14 onto base material 10 to produce substrate 16, which in the example shown in the drawing possesses four layers of copper foil. Resin 14 is similar to the aforementioned resin 13. In the drawing, lamination is carried out on both faces, but lamination may of course be carried out on only one face.

[0012] Next, as shown at operations C and D, laser light 17 is directly irradiated from above copper foil 15 of the laminated substrate, removing copper foil 15 and resin 14, and forming non-through-hole contact hole 18 (variously referred to as a blind via, an interstitial via hole (IVH), and so forth) which reaches the internal-layer copper foil 11 circuit, and furthermore, as shown at operation D, forming contact hole 19 (also referred to as a through-hole) which extends [completely] through substrate 16. Moreover, it goes without saying that a non-through-hole

contact hole can be machined such that the hole is formed to any arbitrary depth. In this manner of implementation, copper foil 15 is not used as a laser light mask. That is, laser light is directly irradiated from above copper foil 15 to accomplish hole formation machining, eliminating [the need for] an operation for etching of contact holes in copper foil 15.

[0013] In addition, as shown at FIG. 2 (a) and FIG. 2 (b), in the present manner of implementation, laser light 17, for which a YAG laser of wavelength 266 nm or 355 nm is used and which possesses a diameter that is at least smaller than the diameter of contact hole 18 or 19, [is irradiated] from above copper foil 15 and is made to revolve so as to spiral from roughly the center of the location at which contact hole 18 or 19 is to be formed, and as this is done the wall of the hole is, as it were, scraped away, and the hole is gradually enlarged outward to machine and form a contact hole of prescribed diameter.

[0014] Moreover, it is sufficient that the laser light be of a wavelength in the ultraviolet region, and in practice any

one of wavelengths 157 nm, 193 nm, 248 nm, 266 nm, 308 nm, 351 nm, or 355 nm may be employed. Furthermore, revolution of the laser light may, as shown at FIG. 2 (a), be such that machining is carried out while laser light of small diameter is made to revolve a plurality of times [i.e., revolutions], or, as shown at FIG. 2 (b), laser light of large diameter, for example 1/2 of the contact hole diameter or larger, may be made to [revolve] for just a single revolution, or [both] may be used in [alternating] half-revolutions.

[0015] Next, as shown at operations E - G in FIG. 1, at operation E, just as is performed during ordinary [i.e., conventional] operations, plating 20 is applied over the entire surface of substrate 16 wherein contact holes 18 and 19 have been formed, and, at operation F, external-layer circuit pattern 21 is formed, following which, at operation G, solder mask 22 is applied, and manufacture of printed wiring board 23 is complete. Moreover, in another manner of implementation of the present invention, a multilayer printed wiring board in which a multiplicity of metal

layers have been laminated may be manufactured by going back to operation B after operation F, carrying out further lamination of metal layers, and [once again] passing through the contact hole machining operation.

[0016] As described above, because contact hole formation machining is carried out directly on the copper foil itself as a result of specification of laser light, the manner of implementation of the present invention permits elimination of etching at locations on the copper foil corresponding to contact holes such as is performed conventionally for the purpose of use [of the copper foil] as a laser light mask. Moreover, because laser light is irradiated while [causing that laser light] to revolve outward in spiral fashion from roughly the center of the contact hole, it is possible to cleanly finish the hole wall of the contact hole and to prevent glass globules (e.g., 5 μ - 50 μ in diameter) produced as a result of melting of glass, for example, where the laser light cuts glass fabric, serving as core material, from being left [in the contact hole], such as occurs conventionally. Complete plating of such glass

globules is difficult, and has been a cause of defective product. Furthermore, because the present manner of implementation permits elimination of [the need for] an etching operation at locations at which contact holes are to be formed, it is possible to prevent subtle disturbances affecting hole diameter and hole position conventionally occurring due to changes in etchant with passage of time.

[0017] *Benefits of the Invention*

As described above, because it permits elimination of etching for contact holes in copper foil or other such metal layers, the present invention permits reduction of work operations while permitting precision to be maintained, and permits simplification of manufacturing processes as well as achievement of reductions in cost. Furthermore, because holes are formed in spiral fashion by laser light possessing a diameter smaller than that of the contact holes [being formed], the holes are cleanly finished, allowing satisfactory plating, and product yield is improved.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1

FIG. 1 contains diagrams showing printed wiring board manufacturing operations in one manner of implementation of the present invention, these being cross-sectional diagrams of the substrate as it passes from an operation A to an operation G.

FIG. 2

FIG. 2 contains diagrams showing one example of a contact hole machining method in one manner of implementation of the present invention, these being plan views showing examples wherein laser light of (a) small diameter and (b) large diameter is made to revolve during machining.

DESCRIPTION OF CALLOUTS

10 Substrate

11 Copper foil

12 Core material

13 Resin

14 Resin

15 Copper foil

16 Substrate

17 Laser light

18 Non-through-hole contact hole

19 Through-hole contact hole

20 Plating

21 Circuit pattern

22 Solder mask

23 Printed wiring board

FIG. 1 [no text captions]

FIG. 2 [no text captions]